

# Using Remote Manager<sup>®</sup> to Diagnose Coyote Springs Plant Chemistry

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## **Introduction**

Coyote Springs Unit 1 is a 250 megawatt station owned and operated by Portland General Electric. Coyote Springs Unit 2 is a 280 megawatt station owned by Avista Corporation and Mirant Corporation and operated by Portland General Electric. At Coyote Springs, iSagacity has partnered with Nalco to provide around the clock chemistry monitoring services. Both Nalco and iSagacity offer monitoring technologies that are both stand alone and synergistic. Nalco's flagship technology is its TRASAR<sup>®</sup> application. TRASAR<sup>®</sup> is a versatile technology that allows Nalco to determine where its products are going during the treatment process and how effectively they are working. It solves two typical problems with today's industrial water treatment systems: overfeeding and underfeeding. TRASAR<sup>®</sup> eliminates the application of unnecessary chemicals, saving the customer money. TRASAR<sup>®</sup> also prevents underfeeding, thus eliminating poor performance and extending equipment run life.

Remote Manager<sup>®</sup> is iSagacity's Internet based data management tool. Remote Manager<sup>®</sup> is accessed through a secure web site hosted in the iSagacity Data Center. iSage Boiler and Cooling Tower are valued added components to the Remote Manager<sup>®</sup> application. iSage Boiler and Cooling Tower are designed for use in monitoring boiler, steam cycle and cooling system performance in industrial or power boiler installations. Boiler, cooling system and other steam cycle parameters can be trended and alerts can be set for key parameters using Remote Manager<sup>®</sup>. iSage Boiler and Cooling Tower monitor the system for abnormal conditions and diagnoses many common problems.

## **Chemistry Programs**

Coyote Springs has employed Nalco Corporation to help manage the steam cycle, boiler, and cooling tower chemistry programs. For Coyote Springs' high pressure boilers, a low concentration phosphate control is employed yielding a pH around 9.5. The intermediate pressure boiler operates at higher phosphate concentrations and maintains a pH around 10.0. Oxygen scavenger is fed only into unit 2 and pH in the pre-boiler steam systems for both units is maintained with a combination of morpholine and cyclohexylamine. The feedwater pH is maintained around 9.5.

The cooling tower chemistry is controlled with a high stress polymer and phosphate chemistry. Feedback control is provided by Nalco's TRASAR<sup>®</sup> technology. Chlorine and bromine are used as biocides. The cooling towers operate at about 4 cycles of concentration and at a pH of about 7.7.

## **Technology Applications**

Application of the Nalco TRASAR<sup>®</sup> technology is described below. Direct, real-time control by TRASAR<sup>®</sup> measures the actual chemical level in the system. Chemical injection systems linked to the TRASAR<sup>®</sup> controller keep the treatment at the target levels, continuously

making automatic adjustments. The results include: greater accuracy, tighter control and better reliability than indirect control.

TRASAR<sup>®</sup> Technology uses a patented fluorescent measurement technique that works as follows:

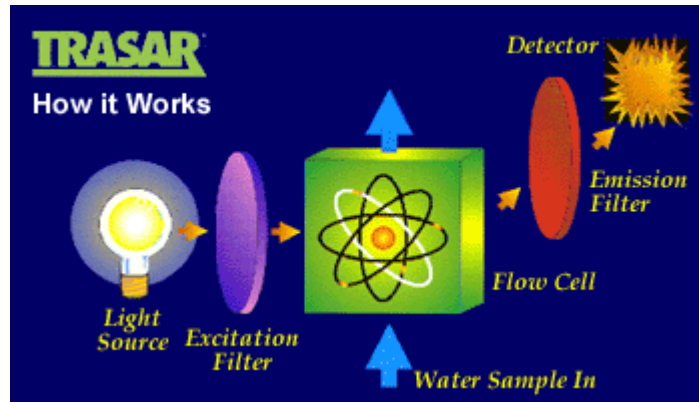


Figure 1 TRASAR<sup>®</sup> and How It Works

- A specific ingredient (a "tracer") is blended into TRASAR<sup>®</sup> treatment products at precise concentrations.
- The product is fed and a sample measured by a fluorometer. Inside the fluorometer, the sample flows through a flow cell in an on-line controller or it is contained in a sample cuvette in a bench top fluorometer.
- The sample is exposed to a filtered light source that causes optical excitation of the fluorescent molecule and ultimately emits a fluorescent light that is read by a detection device. The quantity of emitted light is proportional to the amount of treatment chemical.
- In an automated system, the signal generated is used to monitor and control chemical additions on a "real-time" basis.

iSagacity has developed the Remote Manager<sup>®</sup> technology for diagnosing systems using the Internet. Any process that has measurable and obtainable parameters with characteristic relationships can be monitored and diagnosed with Remote Manager<sup>®</sup>. The application described in this paper is targeted for power plants but is applicable to any process, chemical or otherwise, that benefits from real time diagnostics.

Data can be entered directly into Remote Manager<sup>®</sup> via a web page interface or automatically from SCADA, DCS, ODBC Compliant Databases, Data Historians, or PDAs via the Internet, or company intranet/LAN system.. All data undergoes a series of algorithms. First, the data are screened for their timeliness. Secondly, key pieces of data are reviewed to ensure that the system is in a condition to be analyzed. Remote Manager<sup>®</sup> has the ability to suspend diagnosis if conditions exist where performing a diagnosis is inappropriate or not possible. For example, if the unit is off line, diagnosis is suspended. Thirdly, there are seven layers of screening applied to each data channel to determine its integrity and individual impact on the

overall system. This screening process is the precursor to identifying suspect measurements and abnormal conditions.

Fourthly, a complete system diagnostic routine is applied to the data to determine any abnormal conditions. A library of abnormal conditions is maintained for the system. The diagnostic algorithm first identifies if an abnormal condition exists. Then the diagnosis determines if the abnormal condition is known or unknown. Finally, the diagnosis is revealed on a secure web page for the user. In addition, abnormal conditions can be alerted directly to the users e-mail, text pager, cell phone, or PDA for an immediate response. The diagnostic routine also evaluates each data channel individually and as they interrelate. The routine lists all suspect measurements in a separate area for the user to investigate. A suspect measurement is either an invalid instrument result or a leading indicator of a developing event. Suspect measurements require customer interaction and attention.

Lastly, all data and results are reported on a secure web page for visualization, corrective action statements, and consequences to long-term operation in the diagnosed condition. Individual alerts are also established on data channels as specified by the customer. All information is stored remotely on a SQL back end database.<sup>1</sup>

## **Application Initiation**

Nalco has applied the TRASAR<sup>®</sup> technology to the cooling water systems. TRASAR<sup>®</sup> Technology for Cooling Water Systems is an effective tool that can be used to identify efficiency improvements, solve problems, and improve control in cooling water systems. TRASAR<sup>®</sup> uses a combination of chemicals, service and equipment to provide continuing improvement to customer systems.

Application of Remote Manager<sup>®</sup>/iSage products requires installation of a small software program at the customer's location. This program gathers current data into a file, encrypts the data, and transports the file over the Internet to a secure server. The application is applied on a secure server maintained by iSagacity. The output of Remote Manager<sup>®</sup> is made available to the customer on a secure web page viewable with a web browser (Internet Explorer version 4.0 or higher).<sup>2</sup>

Data is being transferred from two different locations from Coyote Springs to iSagacity. The first data transfer is coming from a dedicated lap top computer that is accessing the PI system and sending data every 30 minutes over a dial up connection. The second data set is coming from the lab computer. The data base file for the Vantage system is being sent via ftp over the Internet to the iSagacity servers automatically upon logon to that system. The ftp software is sending the database file every 10 minutes when the computer is logged in.

## Alerts

Individual data alerts are established in the Remote Manager<sup>®</sup> system and are based on input from the customer. Many of these alerts are also maintained directly on the site computer system. The following table shows the alert set points for the iSage Cooling Tower applications for Unit 1 and Unit 2:

*Table 1 Alert Set Points For iSage Cooling Tower at Coyote Springs*

Location	Parameter	Units	Alert Condition 1 (2 weeks)	Alert Condition 2 (2 days)	Alert Condition 3 (8 hours)
CT	pH	SU	> 7.8 < 7.6	> 8.0	> 8.2
CT	Conductivity	uS/cm	>2300	> 2600	> 2700
CT	Orthophosphate	ppm	< 5	< 4	< 3
CT	Total PO4	ppm	> 9	< 9	< 7
CT	TRASAR <sup>®</sup> (U1)	ppm	< 35	< 33	< 30
	TRASAR <sup>®</sup> (U2)		< 50	< 48	< 44
CT	Free Cl2	ppm	> 0.3	> 0.5	> 0.8

Alerts for the iSage Boiler Application are set as follows:

*Table 2 Alert Set Points For iSage Boiler at Coyote Springs*

Location	Parameter	Units	Alert Condition 1	Alert Condition 2
CD	Cat Cond	uS/cm	>0.5	
CD	O2	ppb	>20	
CD	pH	SU	>9.7	<9.40
CD	SiO2	ppb	>10	
CD	Spec Cond	uS/cm	>15	
FW	Cat Cond	uS/cm	>0.5	
FW	O2	ppb	>10	
FW	pH	SU	>9.7	<9.40
FW	SiO2	ppb	>10	
FW	Spec Cond	uS/cm	>15	
HP	pH	SU	>9.80	<9.30
HPSM	Cat Cond	uS/cm	>0.5	
HPSM	Na	ppb	>10	
HPSM	SiO2	ppb	>10	
IP	pH	SU	>10.2	<9.80
IPSM	Cat Cond	uS/cm	>5	
IPSM	Na	ppb	>10	

## **Cooling Tower Scenario Descriptions**

There are 9 distinct scenarios that are evaluated for the iSage Cooling Tower Application. Four of these scenarios are generic to the Remote Manager<sup>®</sup> technology and five are specific to the iSage Cooling Tower Application. The values for the five specific scenarios are listed in the table below. The following is a description of the five iSage Cooling Tower specific scenarios. Additional scenarios can be added through the use of the form found at the end of this document.

### *Normal Chemistry*

This scenario specifies what is required for normal chemistry conditions.

### *Cooling Water Scaling Conditions*

This scenario complements the current Nalco program in place in the field. It uses data that are not used by TRASAR<sup>®</sup> to determine scaling conditions in the plant. The conditions must exist for 8 hours for this scenario to engage. The scaling conditions are indicated by the Scaling Index, total alkalinity, and the cooling tower pH.

### *Reduced Condenser Performance*

This scenario was designed to complement the current Nalco program for scale inhibition and dispersion. The scenario uses condenser performance issues to determine when potential actions are needed to improve condenser performance. The algorithm focuses on condenser back pressure and cleanliness factor and the conditions must exist for 8 hours for this scenario to engage.

### *Verify Cooling Tower pH Meter*

This scenario was designed to safeguard against an isolated cooling tower pH meter which could lead to excessive fouling of the condenser without proper indication. The scenario uses cleanliness factor, terminal temperature difference, total alkalinity, and the acid pump delivery to determine elevated pH conditions without a pH measurement. The scenario conditions must exist for 4 hours in order to engage.

### *High Biological Demand*

This scenario uses the calculated Bio Index and the measured free chlorine in the water to determine the biological demand in the system. This condition must exist for 4 hours for the scenario to engage.

## **Cooling Tower Special Features**

There are several special features for performance and diagnostics that have been integrated into iSage Cooling Tower.

*Condenser Cleanliness Factor*

The overall heat transfer coefficient is calculated in real time for the main condensers. This value is compared to design data to give a condenser cleanliness factor. This factor is useful in determining the overall fouling conditions of the condenser.

*Condenser Terminal Temperature Difference (TTD)*

The TTD of the main condensers is calculated in real time. This value is useful in trending the performance of the condensers and is based on the calculated steam temperature and the outlet cooling water temperature of the main condensers.

*Cooling Tower Scaling Index*

A scaling index was developed from the calculated hold time index and the cooling tower pH. The scaling index is calculated in real time and is useful in determining scaling conditions due to extensive clean up half lives in the cooling tower. These conditions stress the chemical inhibition properties and potentially allow for scaling to occur.

*Cooling Water Delta Temperature*

The condenser cooling water delta T is calculated for trending purposes as a performance parameter. Elevated delta T's can indicate low cooling water flowrates. Minimized delta T's can indicate fouling.

*Overall Plant Efficiency*

The overall efficiency of the power plant is calculated from the measured load and the calculated heat loss in the main condenser. This indicator is useful for trending general performance.

*Condenser Steam Temperature at Saturation (T<sub>sat</sub>)*

The saturated steam temperature is calculated from the condenser back pressure. This value is used in the calculation of the TTD.

*Cooling Tower Cycles of Concentration*

The cycles of concentration in the cooling towers is calculated from the cooling tower blowdown flowrate and the total make up flowrate. The cycles of concentration are directly related to the cooling tower hold time index.

*Cooling Tower Hold Time Index (HTI)*

The HTI is the cooling tower clean up half life. This is the time that it takes to remove half of the concentration of impurities from the cooling tower. The HTI is dependent on the cooling tower volume, blowdown flowrate, and the make up flowrate.

*Cooling Tower Biological Index (Bio Index)*

The microbiological demand on the cooling tower is related to the free chlorine concentration and the delivery of the chlorine to the system. The higher the Bio Index, the higher the microbiological demand is for a given chemical federate.

## **HRSG Scenario Descriptions**

### *Normal Chemistry*

The scenario specifies the requirements for normal operating chemistry.

### *Small Condenser Leak*

This scenario is designed based on the cooling water and normal steam cycle chemistry. A small condenser leak that is near the alarm levels is modeled to help alert the plant personnel to conditions before they become a threat to unit availability.

### *Large Condenser Leak*

This scenario is also based on the cooling water and normal steam cycle chemistry. A large condenser leak is diagnosed for conditions that are near or above the level where power reduction actions may be necessary.

### *Amine Overfeed*

This scenario maintains the proper relationship between amine concentrations and various system chemistry parameters such as pH, conductivity, and cation conductivity. Amine overfeed is diagnosed when the amine concentrations are maintained outside the normal operating range.

### *Amine Underfeed*

This scenario also maintains the proper relationship between amine concentrations, pH, conductivity and cation conductivity. The scenario alerts plant personnel when low amine conditions threaten the general corrosion rate in the pre-boiler systems and potentially increases the corrosion product (iron/copper) transport to the boilers.

### *Deaerator Malfunction*

This scenario evaluates the removal of oxygen and volatile constituents around the deaerator and alerts plant personnel to degrading equipment conditions.

### *Air In-Leakage*

This scenario evaluates the relationship between oxygen and cation conductivity in the steam cycle to alert plant personnel to excessive air in leakage before condenser performance issues arise.

### *Feedwater/Condensate Dissolved Oxygen Meter Malfunction*

A site specific requested scenario that evaluates the performance specifically of the dissolved oxygen meter that is used for both feedwater and condensate analysis. Malfunctioning of this instrument can falsely indicate a problem with the deaerator operation. This scenario allows distinguishability between these two events.

## **Case Studies**

Remote Manager and iSage Boiler have been employed at Coyote Springs since February 2004. iSage Cooling Tower has been employed since May 2004. As a credit to the staff at Coyote Springs, there have not been any major chemistry upsets identified during this time.

Only a handful of instruments have been identified as out of specification or in need of repair. However, the following minor chemistry events have been recorded to show the efficacy of the Remote Manager<sup>®</sup> technology.

### Deaerator Malfunction<sup>3</sup>

Coyote Springs Unit 1 HRSG was operated for about 7 hours at various loads. The plant deaerator was identified as not functioning properly and the pH program was not controlled per specification. The following table displays key data and the diagnosis made during the evolution.

Table 3 Monitoring and Diagnosis of Steam Cycle Chemistry at Coyote Springs Unit 1

Elapsed Time	Diagnosis	Load	FW O2	FW Cat Cond	FW Sp Cond	FW pH	CD Sp Cond	CD DO
Hours		MW	ppb	uS/cm	uS/cm		uS/cm	ppb
0.0	<b>Suspended</b>	< 10	20.05	10.07	46.13	9.93	15.14	20.04
0.5	<b>Deaerator Malfunction</b>	30	20.05	10.07	35.90	9.90	18.30	20.05
1.0		82	20.05	10.07	41.60	9.88	25.47	20.05
1.5		147	20.05	10.07	50.38	9.88	25.49	20.05
3.4		149	20.05	10.07	50.39	9.96	25.02	20.05
3.9		147	20.05	10.07	50.39	9.97	24.87	20.05
4.4		148	20.05	10.07	50.39	10.01	24.87	20.05
4.9		147	20.05	10.08	49.30	10.02	24.74	20.05
5.4		147	19.98	10.07	44.75	10.03	24.55	14.77
6.2		136	12.79	10.08	42.78	10.06	24.15	10.65
6.7	<b>Amine Overfeed</b>	28	2.79	10.08	42.09	10.07	24.17	8.16
7.2	<b>Suspended</b>	< 10	20.04	10.08	40.72	10.07	23.94	9.59

Note: The yellow shaded data indicate values that are out of specification.

Diagnosis was suspended initially when the unit was off line. Once the unit was returned to service, the Remote Manager technology identified a malfunction in the deaerator. Although this diagnosis was consistent with the data presented, it was slightly in error. Following the series of events, it was discovered that the feedwater and dissolved oxygen measurement was performed by the same instrument. This DO meter was not receiving adequate flow and was reading improperly. After a review of this incident, a second scenario was developed to specifically look for this condition in the feedwater and dissolved oxygen meter. This allows the program to distinguish between a bad instrument that is being used in multiple areas of the plant and a malfunctioning deaerator. Although the diagnosis was slightly in error, *the process allowed the site to focus on the problem area and determine the exact cause of the inconsistent data in a timely and cost effective manner.*

### Amine Underfeed

During a start up, Coyote Springs Unit 1 experienced a variation in pH and conductivity. The iSage Boiler technology identified a loss of amine feed which corresponded to a loss of control of the amine pump. The graphical display of the event below is an annotated output from the web pages. It is important to note that the conductivity and pH meter response times differed. Still the technology was able to properly diagnose the event and communicate this via text messaging to cell phones and e-mails.

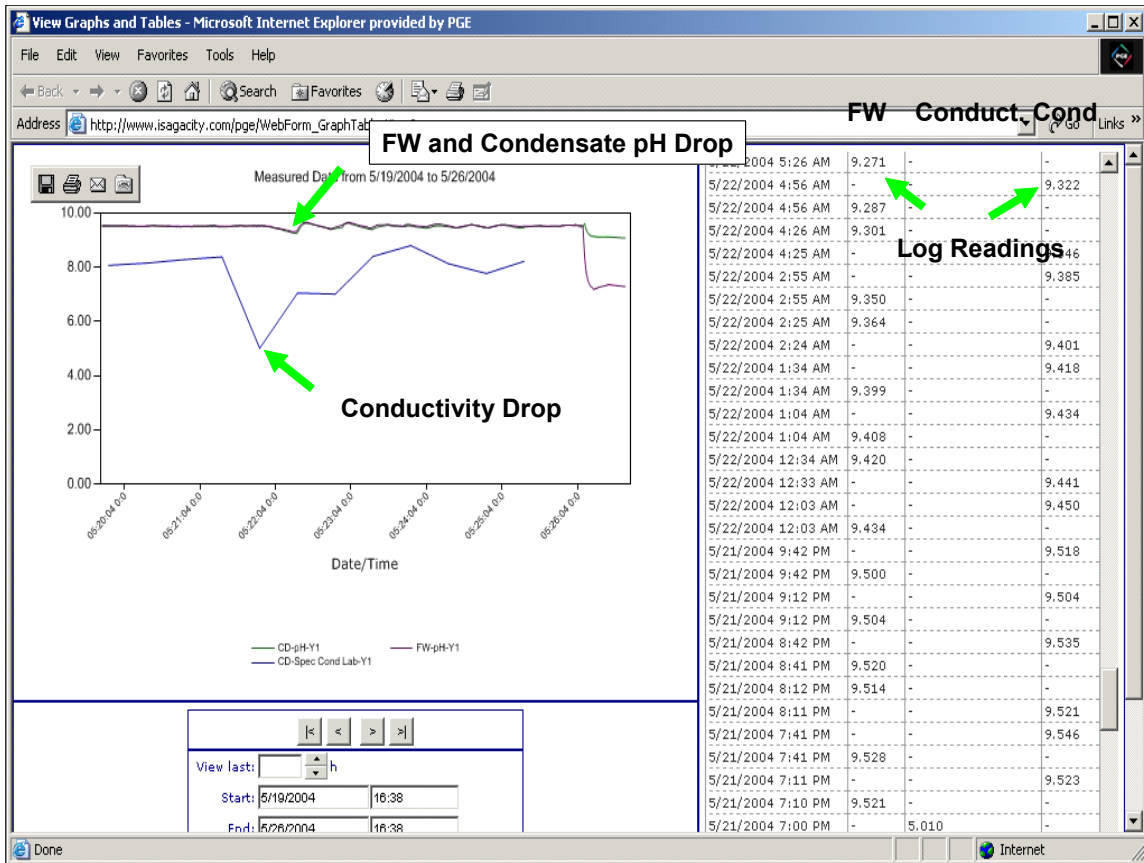


Figure 2 Web Page Display of Loss of Amine Event Coyote Springs Unit 1

The control problem was corrected and the amine feed returned to normal within a few hours.

### Biological Demand Increase

Using Remote Manager<sup>®</sup>, a bio index was created to complement the microbiological monitoring being performed by Nalco. The bio index looks at the actual delivery of biocide and compares it with the amount of free available chlorine in the system. The index increases as the biological demand increases in the system. This information is used with other operating data in a scenario to identify times when the cooling tower is approaching conditions that favor biological fouling, even in the presence of some active biocide. The following chart shows the progression of the bio index in June as the ambient temperature increased. The scenario was not diagnosed, even with an increased bio index. This is a significant difference between diagnosing

an entire system and making deterministic evaluations based on one value or algorithm. As it turns out, the system was maintained free of biological fouling even at elevated bio index levels by the appropriate chemical feed and control in the tower. The overall system diagnosis was correct.

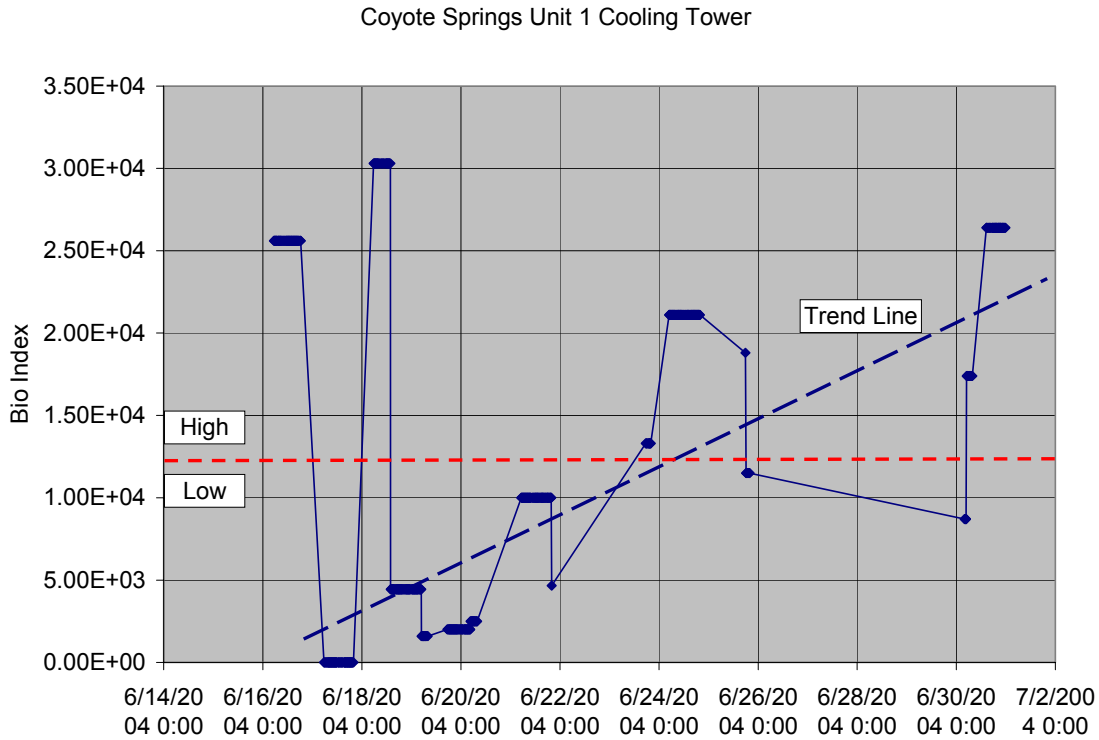


Figure 3 Bio Index vs. Time at Coyote Springs Cooling Tower Unit 1

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